Evaluation Report: Balanced vs Imbalanced Models

1. Balanced Model on Balanced Test

- Accuracy: 0.61
- Observations:
    - The balanced model performs consistently across all classes, with precision/recall around 0.55–0.67.
    - Confusion matrix shows predictions are spread across all 5 classes.
    - Strength: Balanced training allowed fair representation of all ratings.
    - Limitation: Accuracy is modest (61%), indicating that while the model generalizes, it struggles with subtle differences between middle ratings (2★, 3★, 4★).

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2. Balanced Model on Imbalanced Test

- Accuracy: 0.18 (very poor generalization)
- Observations:
    - Model fails on real-world (imbalanced) data, heavily misclassifying most reviews.
    - High class imbalance (5★ dominates) is not handled well by a balanced-trained model.
    - Key Insight: Balanced training improves fairness but reduces robustness when deployed on naturally imbalanced data.

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3. Imbalanced Model on Balanced Test

- Accuracy: 0.20 (very poor)

- Observations:
    - Model predicts mostly 5★ regardless of input.
    - Almost zero recall for classes 2★, 3★, and 4★.
    - Confusion matrix shows overwhelming bias toward 5★.
    - Key Insight: Imbalanced training makes the model biased and ineffective when tested on a fair (balanced) distribution.

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4. Imbalanced Model on Imbalanced Test

- Accuracy: 0.74 (highest overall)
- Observations:
    - Performs very well in the imbalanced test (close to real-world scenario).
    - Excellent performance for 5★ class (recall = 0.96, precision = 0.80).
    - Poor recall for minority classes (e.g., 2★ recall = 0.06, 3★ recall = 0.25).
    - Key Insight: While accuracy is high, it is misleading since the model is mainly correct by predicting 5★ frequently. Minority classes are almost ignored.

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5. Overall Comparison

Model Type	Test Data	Accuracy	Strengths	Weaknesses
Balanced Model	Balanced Test	0.61	Fair across all classes, interpretable	Lower accuracy, struggles on imbalanced data
Balanced Model	Imbalanced Test	0.18	Tries to predict all classes	Fails in real-world scenario
Imbalanced Model	Balanced Test	0.20	Slight ability on 5★	Completely biased to majority

Model Type	Test Data	Accuracy	Strengths	Weaknesses
Imbalanced Model	Imbalanced Test	0.74	Excellent on 5★ (majority class)	Fails minority classes, misleading accuracy

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6. Key Insights

- Balanced Training → Best for fairness across all classes but fails when applied to natural distributions.
- Imbalanced Training → Best accuracy in real-world data, but fails minority classes (not reliable for all ratings).
- Trade-off: Balanced model = fair but less realistic; Imbalanced model = practical accuracy but unfair.

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7. Conclusion

- If the goal is real-world deployment where most reviews are positive (5★), the imbalanced model provides the highest accuracy.
- If the goal is fair classification across all ratings, the balanced model is preferable despite lower accuracy.
- For best performance, consider hybrid strategies:
    - Class weighting or oversampling for imbalanced data.
    - Ensemble of balanced and imbalanced models.
    - Deep learning with weighted loss functions.